Abstract

Current-Controlled Pulse Width Modulated (CC-PWM) Voltage Source Inverters (VSIs) are extensively employed in high performance drives (HPD) because of the considerable advantages offered by them, such as, excellent dynamic response and inherent over-current protection, as compared to the voltage-controlled PWM (VC-PWM) VSIs. Amongst the different types of CC-PWM techniques, hysteresis current controllers offer significant simplicity in implementation. However, conventional type of hysteresis controllers (with independent comparators) suffers from some well-known drawbacks, such as, limit cycle oscillations (especially at lower speeds of operation of machine), overshoot in current error, generation of sub-harmonic components in the current, and random (non-optimum) switching of inverter voltage vectors.

Common problems associated with the conventional, as well as current error space phasor based hysteresis controllers with fixed bands (boundary), are the wide variation of switching frequency in the fundamental output cycle and variation of switching frequency with the change in speed of the load motor. These problems cause increased switching losses in the inverter, non-optimum current ripple, excess harmonics in the load current and subsequent additional machine

heating. A continuously varying parabolic boundary for the current error space phasor is proposed previously to get the switching frequency variation pattern of the output voltage of the hysteresis controller based PWM inverter similar to that of voltage controlled space vector PWM (VC SVPWM) based VSI. But the major problem associated with this technique is the requirement of two outer parabolas outside the current error space phasor boundary for the identification of sector change which gives rise to some switching frequency variations in one fundamental cycle and over the entire operating speed range. It also introduces 5^{th} and 7^{th} harmonic components in the voltage causing 5^{th} and 7^{th} harmonic currents in the induction motor. These harmonic currents causes 6^{th} harmonic torque pulsations in the machine. This thesis proposes a new technique which replaces the outer parabolas and uses current errors along orthogonal axes for detecting the sector change, so that a fast and accurate detection of sector change is possible. This makes the voltage harmonic spectrum of the proposed hysteresis controller based inverter exactly matching with that of a constant switching frequency SVPWM based inverter. This technique uses the property that the current error along one of the orthogonal axis changes its direction during sector change. So the current error never goes outside the parabolic boundary as in the case of outer parabolas based sector change technique. So the proposed new technique for sector change eliminates the 5^{th} and 7^{th} harmonic components from the applied voltage and thus eliminates the 5^{th} and 7^{th} harmonic currents in the motor. So there will be no introduction of 6^{th} harmonic torque pulsations in the motor.

Using the proposed scheme for sector change and parabolic boundary for current error space phasor, simulation study was carried out using Matlab-Simulink. Simulation study showed that the switching frequency variations in a fundamental cycle and over the entire speed range of the machine upto six step mode operation is similar to that of a VC-SVPWM based VSI. The proposed hysteresis controller is experimentally verified on a 3.7 kW IM drive fed with a two-level VSI using vector control. The proposed current error space phasor based hysteresis controller providing constant switching frequency is completely implemented on the TI TMS320LF2812 DSP controller platform. The three-phase reference currents are generated depending on the frequency command and the controller is tested with drive for the entire operating speed range of the machine in forward and reverse directions. Steady state and transient results of the proposed drive are presented in this thesis.

This thesis also proposes a new hysteresis controller which eliminates parabolic boundary and replaces it with a simple online computation of the boundary. In this proposed new hysteresis controller the boundary computed in the present sampling interval is used for identifying next vector to be switched. This thesis gives a detailed mathematical explanation of how the boundary is computed and how it is used for selecting vector to be switched in a sector. It also explains how the sector in which stator voltage vector is present is determined. The most important part of this proposed hysteresis controller is the estimation of stator voltages along alpha and beta axes during active and zero vector periods. Estimation of stator voltages are carried out using current errors along alpha and beta axes and steady state equivalent circuit of induction motor. Using this estimated stator voltages along alpha and beta axes, instantaneous phase voltages are computed and used for finding individual voltage vector switching times. These switching times are used for the computation of hysteresis boundary for individual vectors. So the hysteresis boundary for individual vectors are exactly calculated and used for vector change detection, making phase voltage harmonic spectrum exactly similar to that of constant switching frequency VC SVPWM inverter. Sector change detection is very simple, since we have the estimated stator voltages along alpha and beta axes to give exact position of stator voltage vector.

Simulation study to verify the steady state as well as transient performance of the proposed controller based VSI fed IM drive is carried out using Simulink tool box of Matlab Simulation Software. The proposed hysteresis controller is experimentally verified on a 3.7 kW IM drive fed with a two-level VSI using vector control. The proposed current error space phasor based hysteresis controller providing constant switching frequency profile for phase voltage is implemented on the TI TMS320LF2812 DSP controller platform. The three-phase reference currents are generated depending on the frequency command and the proposed hysteresis controller is tested with drive for the entire operating speed range of the machine in forward and reverse directions. Steady state and transient results of the proposed drive are presented for different operating conditions.